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PRODUCT DESIGN SPECIFICATION
AUTOSPLIT™
SEPTEMBER 30, 1995 : CONFIDENTIAL : REVISION 1.0

Originated by: Thomas A. Genise
Project No.: R-706
Date: September 30, 1995

Statement of Function

This document describes the design requirements for an electronically controlled, partially automated, transmission system based on the R747 transmission, hereafter referred to as **AutoSplit™**

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S. Edelen Manager - Automation Engineering		
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PROPRIETARY NOTICE

NOTICE TO PERSONS RECEIVING THIS TECHNICAL INFORMATION

LINKED SPECIFICATION TREE

The diagram D-1 below illustrates the hierarchy and linkage between specifications which define the AutoSplit. A listing of these specifications may be found in section 2.0.

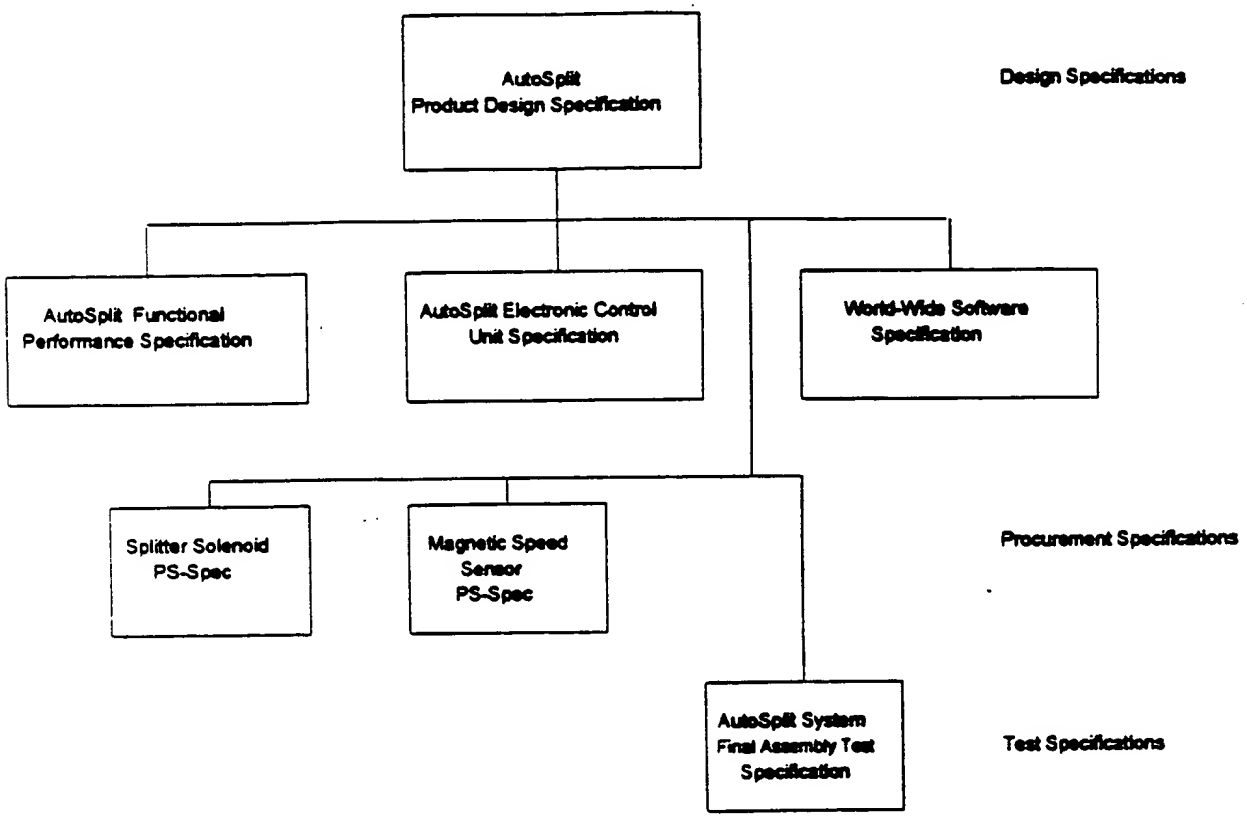

Diagram D-1 - Linked Specification Tree

REVISION LOG

VERSION	SECTION CHANGED	DATE	TYPE OF CHANGE
1.0	-	9/30/95	Initial Version

Reference base specification is 31 July 1990, "AutoSelect Product Design Specification"

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

This specification establishes features, functions, performance and design constraints for an R747-based, Partially Automated Mechanical Transmission system (PAMT), hereafter referred to as AutoSplit.

1.2 Scope

This document describes the on-highway requirements for AutoSplit. These requirements encompass performance, interface, design, serviceability, product assurance, reliability, durability, validation, and quality assurance down to the major component level. The linked specifications, discussed in section 2, are used to further specify components.

1.3 Acronyms and Abbreviations

CAN	Controller Area Network Serial Communication Link
ECU	Electronic control unit, or controller
EOL	End Of Line
GVW	Gross vehicle weight of tractor and trailer.
NA	Not Applicable
OEM	Original Equipment Manufacturer
PAMT	Partially Automated Mechanical Transmission
PN	Eaton Part Number
VDC	Voltage Direct Current
J1939	SAE Recommended Practice for Serial Control and Communications Vehicle Network
J1587	Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications
TL	Truck Load
LTL	Less Than Truck Load

2 LINKED SPECIFICATION LIST AND DOCUMENT CHANGE

2.1 Change Authority

All revisions or changes to this document will be maintained by the System Engineer for the AutoSplit program with approval from the signature list on the cover page. Revisions must be recorded.

2.2 Linked Specification List

The concept of linked specifications mandate that the owners of the specifications listed below be involved in changes. Refer to diagram D-1 at the beginning of this specification.

- AutoSplit Functional Performance Specification
- AutoSplit Electronic Control Unit Specification
- World-Wide Software Specification
- Splitter Solenoid Valve Procurement Specification
- Magnetic Speed Sensor Procurement Specification
- AutoSplit System Final Assembly Test Specification

3 GENERAL DESIGN REQUIREMENTS

3.1 Brief Description of AutoSplit

The AutoSplit system is comprised of an unmodified R747 base transmission including the on-board ECU, modified R747 software, an R747 shift knob modified to include a momentary push-button in place of the splitter switch, a driver display, a slightly-modified R747 wiring harness, a J1587 diagnostic link, and a J1939 communication link to an electronic engine controller. Note that the initial product configuration for the R747 transmission will be similar to the current Super 10.

All "splitter-only" shifts are fully automatic. In addition, all lever shifts feature automatic throttle manipulation and speed synchronization using J1939 engine control for easy lever shifting. This system results in clutch less shifting with no throttle manipulation after a manual clutch start. A simple dash driver display informs the driver of the "best" gear, available gears, and which gear the system is synchronizing for when the transmission is in neutral.

The block diagram in Figure 3-1 below describes the required inputs and outputs (I/O) and provides a general layout of the AutoSplit system. For a more complete understanding of the AutoSplit hardware and interfaces, see the following sections of this document.

Normal AutoSplit operation consists of both driver-initiated (lever) shifts and system-initiated, automatic (splitter) shifts. The normal shift sequence for each of these shifts is as follows:

Splitter-Only Shift

1) The system detects the optimal time to shift based on load, **input_speed**, etc.
2) The system overrides cruise control, engine brakes, throttle, etc. via J1939 engine override commands.
3) The system commands the splitter to neutral and modulates the engine torque to allow splitter disengagement via J1939.
4) The system confirms splitter disengagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
5) The system implements anti-hunting routines.
6) The system modulates **engine_speed** via J1939 to synchronize the splitter for the target ratio.
7) The system senses impending synchronous via **input_speed** and **output_speed** signals.

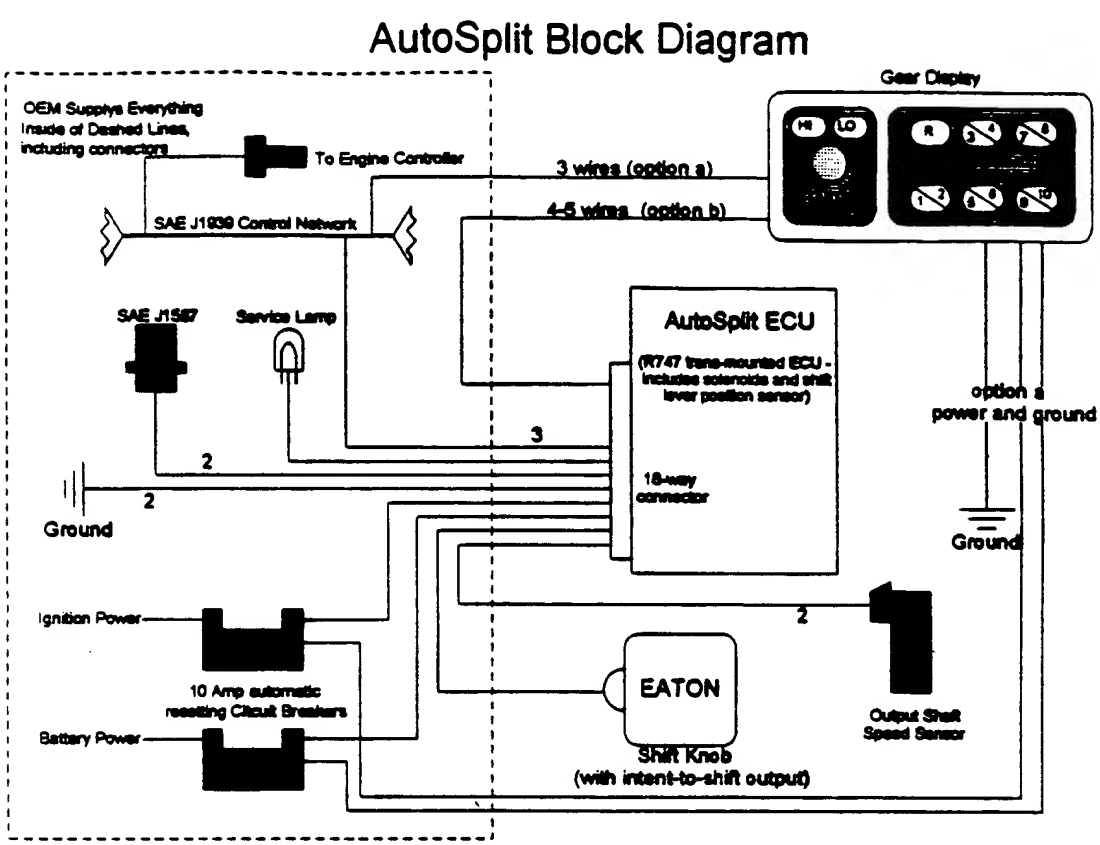

Figure 3-1 - AutoSplit Block Diagram

8) The system commands the splitter toward target gear engagement.
9) The system confirms splitter engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
10) The system commands the engine to reapply torque via J1939.
11) The engine resumes control of the throttle, engine brakes, cruise control, etc.

Lever/Splitter Shift

1) The driver display flashes the available lever position to indicate it is "OK" to shift the lever to that position.
2) When the driver desires to make the indicated lever shift, he or she pulls the lever to neutral while activating the intent-to-shift feature (TBD - either a momentary button, or a force detente in the knob or lever).

3) The system overrides the cruise control, engine brakes, throttle, etc. via J1939.
4) The system commands the splitter to neutral and modulates the engine torque to allow splitter and lever disengagement via J1939.
5) The system confirms transmission neutral via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table, and by the lever position sensor.
6) The system implements anti-hunt routines, commands the splitter to the target position for the new ratio, and modulates the **engine_speed** via J1939 to synchronize the transmission for the target gear ratio.
7) The driver moves the lever into the new position.
8) The system confirms the new gear engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
9) The system commands the engine to reapply torque via J1939.
10) The engine resumes control of the throttle, engine brakes, cruise control, etc.

3.2 Application Requirements and Constraints

3.2.1 Applications

AutoSplit applications include all "on-highway" RoadRanger vocations including Pick-Up and Delivery, LTL, TL, and large and small fleets. Engine applications include all diesel engines supporting the SAE J1939 communications standard and approved for the base R747 transmission.

3.2.2 Weight and Size Constraints

Targets for the AutoSplit components are as follows:

Major Component	Weight	Length	Height	Width
Base R747 Transmission	N/A			
Gear Display	1	2"	x 1.5"	x 3"
Net OEM Effect	1 lb.			

3.2.3 Vehicle Accessories Compatibility

AutoSplit will be compatible with all types of engine brakes and driveline retarders. Engine brakes may be interactive with AutoSplit during a shift sequence.

AutoSplit will be compatible with cruise control systems implemented as part of the electronic engine controls or with aftermarket systems communicating cruise control status over the

SAE J1939 communications link. AutoSplit will be compatible with all types of antilock brake systems.

3.3 Functional and Performance Requirements

This section summarizes the functional and performance requirements that are explained in more detail in the AutoSplit Functional Performance Specification. See that document for a more detailed description of AutoSplit operation.

3.3.1 Functional Requirements

3.3.1.1 Engine Starting

Starting the engine will not require any additional requirements upon the driver or vehicle over that of a base R747 transmission.

3.3.1.2 Shift Decisions

Two types of shift initiations are possible: 1) fully automatic splitter shifts and 2) driver initiated, electronically assisted, lever shifts.

All splitter shifts are initiated and completed by the AutoSplit system without driver intervention. The splitter shift points are throttle-modulated, but may be further modified by the shiftability algorithm, which determines the desirability and/or feasibility of a given shift.

Automatic splitter shift points are selected to provide the best compromise between fuel economy and performance. Shift points are moved toward governed speed when the throttle pedal is fully depressed and chosen to maintain maximum fuel economy during periods of light throttle application.

Driver initiated, or lever, shift points are actually input speeds at which it is "ok-to-shift" to a new gear. Since it is up to the driver as to when the actual lever shift will occur, these "ok-to-shift" points represent the earliest possible point at which the system will allow that lever shift, and are communicated to the driver via the Driver Display.

Driver-initiated lever shifts occur when the driver de-fuels the engine and manually shifts the transmission to neutral, or when he/she pulls the lever to neutral while depressing/activating the intent-to-shift switch, causing the system to de-fuel the engine. The new splitter gear is engaged after the system detects front box neutral.

In all modes, the operator is responsible for controlling the clutch for vehicle launch, lever shifting, and for stopping the vehicle.

The system will utilize predetermined upshift and downshift splitter shift points and lever shift "ok-to shift" points, tailored to the engine. These shift points may be communicated over J1939 or preset at the OEM EOL programming station. In operation during shifting, the system often temporarily modifies the shift points to reduce the possibility of hunting.

3.3.1.3 Driver Display

The Driver Display will have 10 lamps to illuminate the 10 "half-bubbles" corresponding to each of the forward gears. It will also have two lamps to indicate whether low or high splitter gear is chosen for the starting gear. A two-position or momentary button is included on the display face for the driver to select the starting splitter gear. Figure 3-2 below illustrates the required Driver Display appearance and function.

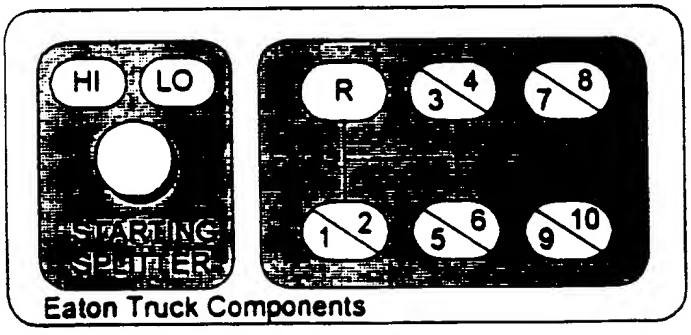

Figure 3-2 - Driver Display

As noted in Figure 3-1, the signals to the Driver Display from the ECU and vice-versa may be transmitted across the J1939 communications link or transmitted directly from the ECU to the display. It is estimated that the direct wiring approach will be significantly less expensive to implement - both in hardware and development cost - than the J1939 version. However, the J1939 version may have advantages in versatility for other products.

3.3.1.4 Special Shift Decisions

When decelerating to a stop or coasting for any period of time in lever neutral, the system will continue to calculate the appropriate gear as the vehicle speed changes, shifting the splitter as necessary. Also, the system will continue to command an engine speed that creates synchronous for the recommended gear. After 3 seconds of neutral (if the throttle is released), the system will stop requesting an engine speed and allow engine idle until the driver again depresses the throttle. This recommended gear/lever position will be indicated to the driver via a flashing lamp on the driver display.

Skip shifting is not allowed or provided for with the AutoSplit due to the wide ratio steps. The system will be able to recover from the driver engaging the lever in a position other than the Driver Display is recommending. However, engagement in this situation would be difficult and would usually require the driver to disengage the master clutch.

3.3.2 Mechanical Performance

3.3.2.1 Shifting

From the driver's perspective, automatic shifts occur once after every lever shift. The AutoSplit system communicates with the electronic engine controller to initiate and complete splitter shifts.

The system will assist the driver with lever engagements by using electronic throttle synchronization during lever shifts. Several examples of shift combinations are presented in Figure 3-3 on the next page.

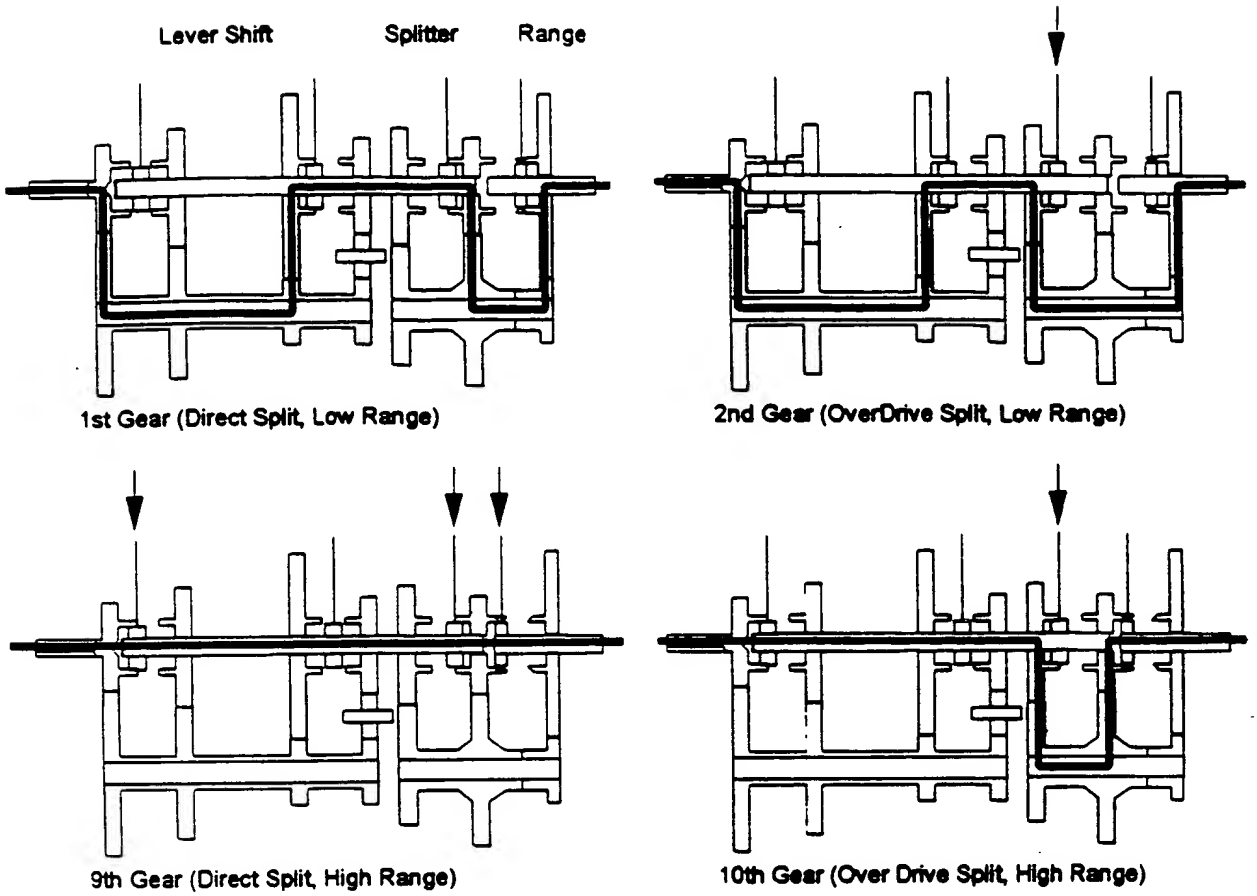

Figure 3-3 - AutoSplit Shift Combination Examples

3.3.2.2 Shift in Progress

The mechanical shift process is divided into three base shift types: a base manual front box shift, a splitter shift, and a range change. Several combinations of each are possible but the most frequent are splitter only, or manual front box and splitter change (lever shifts). The sequence of events to perform any combination of shift is described below and also illustrated generically in Figure 3-4.

Disengage Front Gearbox (Lever Shift) - The driver initiates a lever shift by pulling the lever to neutral. If the intent-to-shift switch is activated, the splitter is commanded to neutral and engine torque is commanded to dither around zero driveline torque. The splitter physically moves to neutral when the driveline torque is at or near zero.

and/or

Select Splitter State (Splitter Shift) - The system determines a splitter shift is required, commands the splitter to neutral, and the engine torque is commanded to dither around zero driveline torque. The splitter physically moves to neutral when the driveline torque is at or near zero.

Sense Neutral (Lever Shift & Splitter Shift) - Gearbox neutral is detected by differences between input and output speed as well as by the lever position sensor.

Select Splitter State (Lever Shift) - Once front box neutral is confirmed for driver initiated lever shifts, the splitter will be commanded to the state for the new gear. It will move into the new splitter engaged position immediately.

Calculate Synchronous Engine Speed (All Types) - Synchronous speed targets will include a synchronous error band and also compensate for the effects of shafts accelerations and oscillations.

Throttle Control to Synchronous (All Types) - The system will control the engine speed in order to synchronize the countershaft and mainshaft. For upshifts, this usually means decreasing the engine speed to let the input speed pass through synchronous. For downshifts, this usually means increasing the engine speed to allow input speed to pass through synchronous. Engine speed control to assist synchronization is used for lever shifts also.

Engine speed control is accomplished through communications with the electronic engine controller over the SAE J1939 communications link by requesting the engine to perform various speed and torque functions.

Engage New Gear (Splitter Shifts) - When synchronous rpm is within a valid gear ratio ±error as measured by the input speed and output speed, the splitter is commanded to engage the new gear. When gear engagement is confirmed, full throttle control is returned to the driver.

Engage New Gear (Lever Shifts) - During lever neutral, the engine is commanded to near (35 rpm below) synchronous speed for the new ratio. The driver engages the lever into the new gear. When gear engagement is confirmed, throttle control is returned to the driver.

3.3.2.2.1 Complete and Verify Shift

The shift is considered complete when speed sensors confirm the correct ratios. If the system senses that synchronous rpm is out of range, it returns to the "Shift in Progress" sequence.

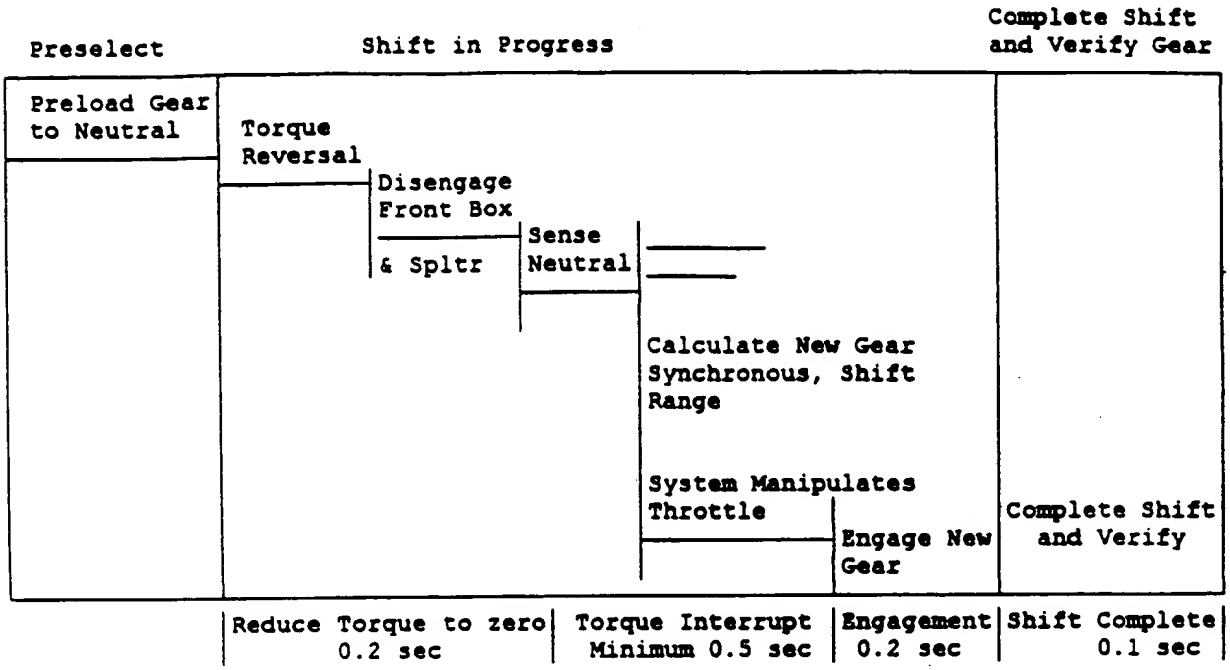

Figure 3-4 - AutoSplit Shift Sequence

3.3.2.3 Shift Quality

AutoSplit shift quality shall meet or exceed that demonstrated by a skilled professional driver shifting a non-synchronized R747 transmission with a manual clutch.

3.3.2.4 Special Shifting Conditions

3.3.2.4.1 Range Synchronizer Protection

AutoSplit will incorporate the same range protection methods as the base R747 transmission.

3.3.2.4.2 Upshifting on Upgrades

No additional skill or direction will be needed by the driver to make upshifts on upgrades beyond that required for the base R747 transmission. AutoSplit will utilize the same method of increasing shiftability on grades as the R747 transmission. The R747 method

consists of increasing the synchronous window size as a function of output shaft deceleration. The algorithm calibrations may be changed for AutoSplit. In addition, the Shiftability Algorithm - similar to that developed for AutoShift - will be used to determine the desirability and/or feasibility of a given upshift and either inhibit the shift or trigger an engine compression brake or engine inertia brake (if so equipped) to decelerate the engine faster.

3.3.2.4.3 Cold Weather Operation

Cold Weather Operation will not place greater skill demands on the driver than normal.

Below 10 degrees Celsius oil temperature, Warm Up Requirements may be recommended. Idling with the transmission in neutral, and with master clutch engaged for as much as 10 minutes is acceptable.

A Low Temperature Shift Strategy is acceptable when transmission oil temperature is below 25 degrees Celsius. At this time, less than optimal shift quality is also acceptable.

3.3.2.4.4 Operation During Skids or Slick Surfaces

If a skid occurs on ice or slick road surfaces, AutoSplit will remain engaged in the current gear or will move to a splitter neutral position if currently processing a shift. The transmission will remain in gear or in neutral until the skid event expires. AutoSplit will not initiate shifts if the wheels are spinning on slick surfaces. Shifts will be prohibited until the wheel spin is controlled. AutoSplit will process requests from an ABS system to shift to neutral during skid events.

3.3.2.4.5 Electronic Subsystem Compatibility

AutoSplit will be compatible with and will not interfere with the performance of other electronic control systems on the vehicle such as cruise control, anti-lock brake systems, and traction control systems.

3.3.3 Electrical Performance

AutoSplit will operate in 12 VDC, negative ground, heavy and medium duty automotive systems. For 12 VDC systems, the normal operating range is defined by an operating trapezoid between 9, 14 and 16 Volts DC, as illustrated in Figure 3-5.

In Figure 3-5, voltages in excess of 14 VDC at high temperature are associated with regulator failure. It is presumed that these will lead to battery failure. The Low Battery Margin zone allows for an idling vehicle with a heavy electrical load and fully discharged

battery. If the system voltage exceeds 16 VDC, splitter control will be disabled.

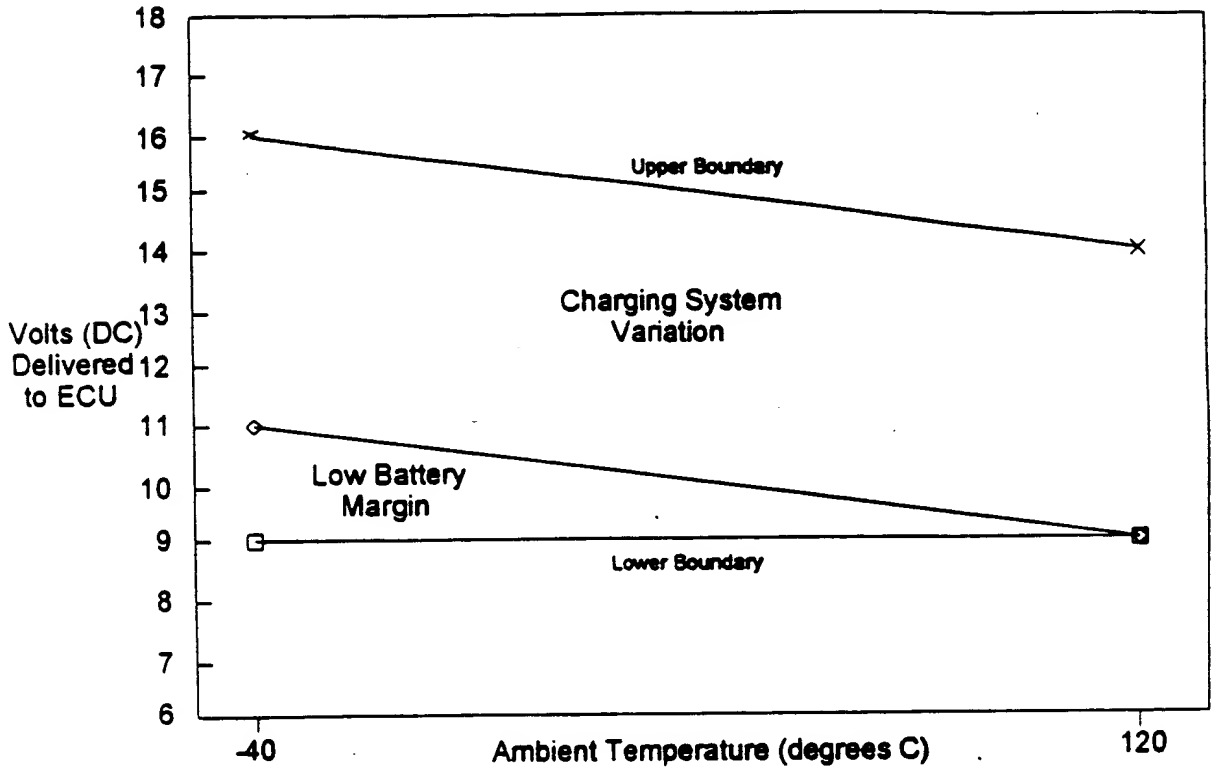

Figure 3-5 - Normal Operating Voltage

4 COST, RELIABILITY, AND DUTY CYCLE

4.1 Cost

Without options, and at high volumes, the AutoSplit cost constraint is a $TBD premium over the base R747 transmission.

System costs will be based upon 10 thousand units per year. Component costs may be based on commonality of components with other products.

AutoSplit Standard Manufacturing Cost (over the cost of a base R747 transmission) is apportioned as follows:

Annual Quantity	10,000
Transmission Harness (mods)	$ 10
Modified Shift Knob	$ 0
Driver Display	$ 50
Added Final Assembly & Test Cost	$ 5
Total	$ 65*

* Above are estimates only since the R747 transmission and Driver Display are not completely defined.

4.2 Reliability

The AutoSplit reliability, relative to section 4.3, is apportioned as follows:

	Reliability	
Transmission Harness & Knob	R=.993	
Driver Display	R=.995	
Transmission (incl. ECU)	R= ??	(per R747)
Total	R= ??	

4.3 Duty Cycle

AutoSplit will be designed for 500,000 miles of the VMS USA 1 route. Typically, 10 speed AutoSplit vehicles will accrue 125,000 to 150,000 miles per year and about 2 split shifts per mile. The GVW for these vehicles will vary from 15,000 lbs to 120,000 lbs.

5 ENVIRONMENT

AutoSplit will have an environmental spectrum under which it must perform normally and conditions under which it must simply survive. Survival conditions are defined in TEES-21 and SAE J1455.

5.1 Natural Environment and Mechanical Abuse

AutoSplit must perform all functions as specified over the following range of conditions:

Ambient Temperature:	-40 to 121 Degrees Celsius (on transmission) -40 to 85 Degrees Celsius (in cab)
Transmission Oil:	-40 to 121 Degrees Celsius 149 Degrees Celsius intermittent
Shift quality:	May be reduced when transmission oil temperatures are less then -25 Degrees Celsius as specified in section 3.3.2.4.3 COLD WEATHER OPERATION.
Air Regulator Input:	Vehicle system air from 60 psi to 150 psi.
Shifting:	Densities as high as 5 shifts per mile.

Outside of the conditions listed above, AutoSplit may override normal procedures to protect the user, engine, or itself from harm.

5.2 Electrical Environment

Supplemental to TEES-021 and SAE J1455, AutoSplit must perform normally over the following range of vehicle conditions:

Operational voltage range is 9 to 16v for 12v AutoSplit systems. Refer to section 3.3.

5.3 AutoSplit Legal Environment

FMVSS 121:	Applies to air brake systems.
FMVSS 101:	Applies to controls and displays.
FCC Part 15:	Applies to RF signals generated by the system.
ACOUSTIC:	Eaton internal transmission noise target of 87 Dba.

6 AUTOSPLIT INTERFACE CONSTRAINTS

6.1 Mechanical Interfaces and Constraints

6.1.1 Transmission Mechanical Interface

Initial development efforts will focus on the R747 10-speed transmission (Super 10 - type) with no changes to the base transmission.

AutoSplit will offer provisions for two, $^{3}/_{4}$-16 threaded, OEM magnetic output shaft speed sensors.

6.1.2 Master Clutch and Throttle

An interface to a electronic engine controller meeting the requirements of SAE J1939 is required.

6.2 Electrical/Electronic Interface and Constraints

AutoSplit will operate with negative ground, electrical systems. Electrical Connections will be uniquely keyed to prevent misconnecting incompatible devices. Electrical System Characteristics must be sufficient to supply a minimum of 9 VDC in order for the AutoSplit to meet specifications. The AutoSplit will put no more than the following demands on the vehicle electrical system:

- Primary Electrical Power will be a direct line to the primary battery cable with degraded Resistance less than 0.010 Ohms, including ground provisions. The conductors providing system power must be capable of sustaining 15 amps continuous current and current spikes up to 45 amperes. The power path should include a fuse link or circuit breaker to provide short circuit protection.

- Fused Secondary Electrical power will be switched power from the vehicle with a degraded resistance of no more than .10 Ohms, conductors capable of sustaining 5 amperes continuous current, and a fusible link to provide short circuit protection.

- Ignition Switch "Run" Position is an input to the ECU.

Reversed Polarity Situations are not part of the normal operating spectrum for AutoSplit.

- AutoSplit will not operate under reverse polarity conditions.

- Battery , or reversed battery voltage from any wire under the control of the OEM will not damage components in AutoSplit.

6.3 Control/Software Interfaces and Constraints

SAE J1924/J1587/J1708 will provide microprocessor communication protocol during assembly and test. All AutoSplit adjustments will be performed through this interface with a Hand Held Diagnostic Tool. Also, OEM or field calibration of specific engine and vehicle parameters such as rated rpm, peak torque rpm, and axle ratio will be made through this interface. Software and hardware will provide for storage, retrieval, and changes to calibration information.

The Diagnostic Serial Interface will originate from ECU and the connector shall be located in accordance with SAE requirements. SAE J1708/J1587 diagnostic hardware/software will reside within AutoSplit.

7 MANUFACTURING, PURCHASING AND QUALITY TARGETS

7.1 Final Assembly and Calibration

7.1.1 Eaton Final Assembly and Calibration

Final Assembly and Calibration Targets apply to AutoSplit comprised of a base manual transmission with shift knob and driver display. Final assembly will utilize common fasteners and conventional tools.

Eaton AutoSplit Component Calibration will not be necessary as the sub-assemblies will be self calibrating.

7.1.2 OEM Final Assembly Targets

Vehicle Harness and Relay requirements will be provided by Eaton.

OEM Final Assembly of AutoSplit will be no more complex than:

1) Installation of the chassis wiring harness, relay and fusing.
2) Installation of the transmission package.
3) Installation of the dash Driver Display and shift knob.
3) Master clutch linkage adjustment.
4) Installation of the cab wiring harness and fusing.
6) Making required electrical and pneumatic connections.
7) Optional Final system programming and calibration via the diagnostic link.

7.2 Final Test and Certification

Eaton Subassembly Tests will be conducted before installation or shipping, as appropriate. Subassembly tests can be manual or automatic depending on part complexity and the number of parameters required for unit test. All parameters will be determined jointly with Manufacturing and Product Engineering. Sub-Assembly Test Time - including hook-up, test, and disconnect - will not exceed 75% of assembly time.

The major transmission assembly will be tested similar to the standard RoadRanger product. If AutoSplit Fails the Final Tests, in-plant methods will be available to statistically isolate the problem.

7.3 Storage and Shipping

AutoSplit major assembly storage and shipping will be similar to the R747 transmission.

8 SERVICE

8.1 Service Level

In addition to serviceability of the host transmission, the minimum acceptable service level for AutoSplit will include the major subassemblies, sensors and transmission harness. (see 8.4)

8.2 Serviceability and Service Time

8.2.1 Serviceability

Service Tools consist of a Hand Held Diagnostic tool for J1587 diagnostics, basic mechanic hand tools, a common Volt Ohm Meter (VOM), and a tool to monitor the J1939 data link.

Service Documents developed and maintained for AutoSplit will include:

- Service Manual: Consists of disassembly instructions as well as basic scheduled maintenance requirements.
- Troubleshooting Guide: Consist of fault isolation and detection techniques, test procedures to be used in troubleshooting the AutoSplit.
- Illustrated Parts List: Consists of a listing of all service components, assemblies, and kits to be provided for the AutoSplit.
- Driver's Instructions: Consists of general operating instructions as well as lubrication requirements, preventative maintenance, and special features of the AutoSplit.
- Installation Instructions: Consist of unit removal and replacement instructions as well as in-vehicle assembly and component change-out instructions.
- Small Scale Print: Consists of a single reduced scale AD drawing to represent the AutoSplit.

Service Training will consist of a three day, four-part program covering the theory of system operation, system overhaul, vehicle operation, diagnostic strategy and a practical diagnostic exercise.

Towing Requirements for an AutoSplit are the same as the standard product. TEP-022 testing will not induce any failure modes not

already present in the host transmission.

8.2.2 Service Time

The average time for a trained mechanic to isolate a fault to the replaceable unit will be less than TBD hours. Excluding driver detection, service queue and towing, the mean service time for AutoSplit calculated from the table in section 8.4 will be less than TBD hours.

8.3 Fault Detection and Isolation

Design measures will support fault tolerance conventions detailed in Appendix B.

Given the occurrence of a fault, detection falls into three categories:

1. Proactive : Fault Tests of functions prior to exercising them.
2. Reactive : Fault Tests of functions while exercising them.
3. Corrective: Diagnostics tests to isolate and confirm faults.

The preferred fault detection strategy is to use proactive tests, warn the driver and store malfunction codes when incorrect responses are received, then enact "fail soft" procedures. The first proactive measure is to ensure, whenever practical, that a shift can be completed prior to shift initiation. Continuous operation tests will support this strategy by monitoring critical components and parameters like speed sensors, vehicle voltage, and ECU output driver circuits.

If a shift cannot be completed, AutoSplit will remain in the current gear until a shift is requested which a degraded AutoSplit can perform. Within the bounds of Appendix B, the AutoSplit may improvise the shift strategy when operating in a degraded mode. Worst case fallback will be a 5 speed (lever shifts only) mode.

Field Data Acquisition will exist for any input/output parameters available to the diagnostic data link.

8.4 Average Cost To Repair

The Average Cost to repair AutoSplit (using 10,000 unit cost structure) calculated using values from the Table Below.

Serviceable Component	Relative Replacement Frequency	Hours to Diagnose Failure	Hours to Replace Component	Cost of Component to Eaton
Transmission Manager ECU				
Transmission Wiring Harness		TBD		
Transmission Speed Sensors				
Base Transmission				
System Resultant				

The resultant AutoSplit weighted average repair times, and Eaton component costs are TBD hours, and $TBD respectively. These figures do not include costs and idle time associated with operator detection of the fault and idle time, towing, service queue or replacement vehicle rental.

APPENDIX A - APPLICABLE DOCUMENTS

CITED DOCUMENTS LISTING

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design(Heavy Duty Trucks) Jan 88.

Eaton Truck Components Operations North America, Engineering, Standards Manual, Volumes 1, 2, 3 and 4.

Society of Automotive Engineers, "SAE Handbook" Volumes 1,2,3 and 4, Copyright 1989, the Society of Automotive Engineers.

Society of Automotive Engineers,"Electronic Data Interchange Between Microprocessor Systems in Heavy Duty Vehicle Applications", SAE J1587, January 1988, Revised January 1989.

Society of Automotive Engineers,"Recommended Practice for Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications" SAE J1708, June 1987.

Society of Automotive Engineers,"Recommended Practice for Serial Control and Communications Network (Class C) for Truck and Bus Applications" SAE J1939, June 1992 Draft.

International Special Committee On Radio Interference (CISPR), Test Levels and Methods of Measurement of Radio Interference From Vehicle Components 150 kHz to 108 MHZ, Draft dated March 1989.

REFERENCE DOCUMENTS LISTING

Engine Match Chart For Eaton Fuller Transmission, Eaton Corporation, Transmission Division FUL-69-R5 April 1989.

P. Menig, "Automation Product System Considerations", Eaton Corporation Transmission Division Internal Correspondence dated 27 January 1993 (See Appendix B).

T. Genise, "Fingertipper Program Summary of Progress to Date", Eaton Corporation Research and Development - Detroit Center Internal Correspondence dated 1 September 1989.

Federal Motor Vehicle Safety Standards (FMVSS) #124, Accelerator Control Systems.

J. Steeby, T. Genise, "Method For Zero Rake Lever Shift Engagements Using Automated Splitter Control", Patent Disclosure.

APPENDIX B - AUTOMATION PRODUCT SYSTEM CONSIDERATIONS
January 27, 1993

1) System shall be designed so that it does not prevent the operator from stopping the vehicle under all single point failure conditions, including loss of power.

2) System shall be designed such that upon single point loss of electric or pneumatic supply power, the system shall keep the driveline engaged if it was engaged, and disengaged if it was disengaged at the time of the power loss.

3) System shall make no latent changes to driveline torque while parked following normal shutdown sequence.

4) Properly installed and maintained, the automated system shall not prevent the throttle from either returning to idle or following the pedal on loss of power.

5) Automatic clutch products must be able to disengage the driveline using battery and/or other reserve power only.

6) With proper procedures followed, no unintended vehicle motion shall occur when starting or stopping the engine.

7) System shall not prevent going to WOT (Wide Open Throttle) to start the engine.

8) Upon power up, the system shall complete a diagnostic check of itself and will not allow vehicle operations if 1) through 7) are violated.

9) Under normal operating conditions, neutral (a disengaged driveline) shall be available to the driver upon request.

10) The system shall provide an option to allow the driver to prevent the transmission from up shifting.